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Harvest maturity for fruit quality in mango (*Mangifera indica* L.) CV. Ratna and Mallika

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Abstract

An investigation was carried out with an objective to determine the ideal harvesting stage for fruit quality of two important mango varieties viz. Ratna and Mallika under Kerala conditions. The experiment was carried out at the Department of Post-Harvest Technology, College of Agriculture, Vellanikkara, Thrissur, Kerala during 2019- 21. Flowers were tagged during fruit set and observations on physical characters, biochemical parameters of fruit and stone were taken at different stages of growth along with organoleptic evaluation for fruit quality. It is understood from the current study that the ripe maturity stage in cv. Ratna is at 110 days after fruit set (DAFS) with accumulation of 1107.75 HU and in cv. Mallika it is 140 DAFS with accumulation of 1507 HU in Kerala. Both the cultivars reported better physical and biochemical parameters like TSS, sugar, ascorbic acid, total carotenoid, β -carotene, and crude fibre with less acidity, total phenol, total chlorophyll and maximum marketable fruits with good quality parameters.

Keywords: Day after fruit set (DAFS), fruit quality, maturity, Heat units (HU), *Mangifera indica* L., organoleptic, fruit quality

Introduction

Mango (*Mangifera indica* L.) rich in carbohydrates, proteins, vitamins, calcium, iron, and phosphorus, is known as the “King of fruits”. India is the world’s largest mango producer, accounting for 42.2 percent of global production (Madhavan *et al.*, 2019) ^[14] and it has a unique position in India, as the national fruit. Acceptability of mango fruit is based on inherent quality factors such as cultivar, harvest ripeness, pre- and post-harvest handling procedures etc. (Kader 2008; Brecht *et al.*, 2010) ^[11, 4].

Flowering begins during November –December in Kerala due to the atypical agro climatic conditions and hence mango from Kerala is the first to appear in Indian market. In Kerala local varieties like are grown in commercial scale and the national varieties, Alphonso, Bangalora, Banganpally, Sindhuram, Neelam Mallika and Ratna are introduced. Hence an investigation was carried out to find out the proper maturity stage, of the varieties Ratna and Mallika for improving quality.

Materials and Methods

The study was carried out in the department of Post-Harvest Technology, College of Agriculture, Vellanikkara, Thrissur, Kerala situated at latitude of 10.32 °N and longitude 70.10 °E with typical tropical humid climate. During the period of study, the highest mean monthly temperature recorded was in the month of March (36.80 °C) and the lowest mean monthly temperature was in the month of December (32 °C) according to meteorological data recorded at College of Agriculture, Vellanikkara. The mango varieties Ratna and Mallika, introduced to Kerala during 1998 grown as high density planting (HDP) in the mango orchard were used for the study. The flowers were tagged during November 2020 at the time of flowering and initial fruit setting period. Tagging the flowers on specific dates, were done to collect the fruits at different maturity stages, from 90 days onwards.

Growth stages of the fruit, as number of days from fruit set till maturity, were considered as treatments as follows. T₁ (fruits harvested at 90 DAFS), T₂ (100 DAFS), T₃ (110 DAFS) with in cv Ratna. In cv. Mallika there were four treatments viz., T₁ (90 DAFS), T₂ (110 DAFS), T₃ (120 DAFS), T₄ (140 DAFS) with 4 replications and the experiment was laid out in Completely Randomized block Design Observations on physical characteristics including length diameter of fruit and stone measured with vernier calipers, fruit and stone weight by

using digital balance, peel and pulp colour, shoulder development, stone colour and texture by panel test as per the descriptors of IPGRI, (2006) [10]. The firmness of the fruit was measured by means of penetrometer (Vaiseshika digital force gauge, model 6003E). The biochemical characters like acidity, sugars and crude fibre (AOAC 2000) [11] method, ascorbic acid, total carotenoid, β -carotene and total phenol (Sadasivam and Manickam, 1996) [17] were determined. Heat was calculated by the method suggested by Halepotara *et al.* (2019) [9] and organoleptic evaluation on nine-point hedonic scale.

Results and Discussion

In cv. Ratna it is revealed from the data that no significant variation was observed between three maturity stages in specific gravity, length, diameter and weight. In cv. Mallika, significant difference in all the physical parameters and length varied from 18.45 cm at 90 DAFS and 14.28 cm at 140 DAFS whereas diameter varied from 33.93 cm at 90 DAFS and 28.03 cm at 140 DAFS. Mannan *et al.* (2003) [13] reported that in mango fruit length ranged from 6.33cm to 15.53cm in different cultivars. Maximum fruit weight was recorded when fruit were harvested 90 DAFS (859.4 g). The difference in

fruit weight could be due to varietal or genetic characteristics, environmental factors and management practice and Specific gravity was lowest (1.05) when fruits harvested 140 DAFS in cv. Mallika and it was similar with study conducted by Hada and Singh (2018) [18].

Fruit firmness decreases towards maturity in both the cultivars. In cv. Ratna lowest firmness observed when fruits harvested 110 DAFS (1.40 Kg/cm²) and in cv. Mallika it is 140 DAFS (0.73 kg/cm²). According to Shattir *et al.* (2010) [18], the decrease in flesh firmness is due to changes in cell wall, which are linked to the action of hydrolytic enzymes on the cell wall.

In cv. Ratna the stone length was highest when fruits harvested 90 DAFS (8.16 cm), stone diameter was highest in 110 DAFS (10.68 cm) and stone weight was highest when fruits harvested 110 DAFS (44.51cm) as shown in the Table 3. In cv. Mallika both stone length and diameter was highest when fruits harvested 90 DAFS (14.84 cm, 25.16 cm) respectively and maximum fruit weight was observed in 140 DAFS (66.73 g) as shown in the Table 4. Soil, environmental conditions, and genetic influence may all play a role in stone weight variation.

Table 1: Physical parameters of mango cv. Ratna

Treatments	Specific gravity	Length (cm)	Diameter (cm)	Weight (g)	Peel colour	Pulp colour	Shoulder development	Fruit firmness (kg/cm ²)
T ₁	1.18	10.73	25.24	364	G	LY	Raising and then rounded	6.07
T ₂	1.16	10.61	25.26	383.94	GY	LY	Raising and then rounded	2.87
T ₃	1.03	10.44	26.1	358.8	GY	O	Raising and then rounded	1.40
SE(d)	0.095	0.274	0.548	27.50	-	-	-	0.298
CD	NS	NS	NS	NS	-	-	-	0.66

T₁- 90 Days after fruit set, T₂- 100 Days after fruit set, T₃-110 Days after fruit set LY- light yellow, O- orange, GY- greenish yellow, G- green

Table 2: Physical parameters of mango cv. Mallika

Treatments	Specific gravity	Length (cm)	Diameter (cm)	Weight (g)	Peel colour	Pulp colour	Shoulder development	Fruit firmness (kg/cm ²)
T ₁	1.18	18.45	32.68	859.4	G	LY	sloping abruptly	9.04
T ₂	1.09	14.28	30.12	833.68	GY	LY	sloping abruptly	7.11
T ₃	1.08	17.38	33.93	706.55	GY	Y	sloping abruptly	1.80
T ₄	1.05	14.80	28.03	623.95	GY	GY	sloping abruptly	0.73
SE(d)	0.034	0.631	0.871	40.114	-	-	-	0.407
CD	0.08	1.39	1.92	88.37	-	-	-	0.90

T₁- 90 Days after fruit set, T₂- 110 Days after fruit set, T₃-120 Days after fruit set, T₄- 140 Days after fruit set. G- Green, GY- greenish yellow, LY-light yellow, Y- yellow, GY-golden yellow

Table 3: Stone character of mango cv. Ratna

Treatments	Length (cm)	Diameter (cm)	Weight (g)	Colour	Texture
T ₁	8.16	9.84	34.87	Y	Coarse
T ₂	7.96	10.26	41.23	Y	Coarse
T ₃	7.49	10.68	44.51	DO	Coarse
SE(d)	0.219	0.184	0.880	-	-
CD	0.48	0.41	1.94	-	-

T₁- 90 Days after fruit set, T₂- 100 Days after fruit set, T₃-110 Days after fruit set, Y- Yellow, DO- dark orange

Table 4: Stone character of mango cv. Mallika

Treatments	Length (cm)	Diameter (cm)	Weight (g)	Colour	Texture
T ₁	14.84	25.16	51.45	LY	Soft
T ₂	14.18	16.84	64.19	LY	Soft
T ₃	12.81	14.91	65.25	LY	Soft
T ₄	11.83	12.63	66.73	LY	Soft
SE(d)	0.848	1.082	2.139	-	-
CD	1.87	2.38	4.71	-	-

T₁- 90 Days after fruit set, T₂- 110 Days after fruit set, T₃-120 Days after fruit set, T₄- 140 Days after fruit set, LY- light yellow

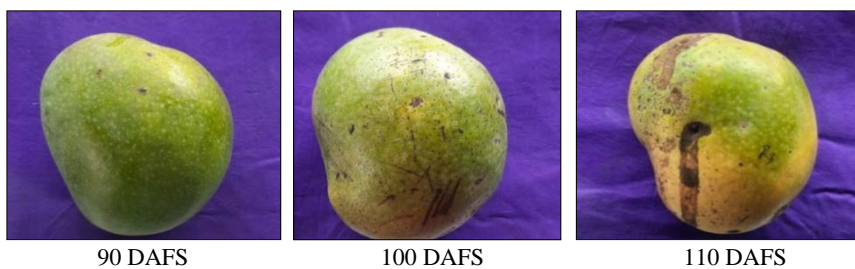


Plate 1: Growth stages in mango cv. Ratna



Plate 2: Growth stages in mango cv. Mallika

TSS was less during initial stage of growth and it increased during maturation and in mango cv. Ratna TSS was lowest in 90 DAFS (9.24 °brix) and highest at 110 DAFS (21.12 °brix). In cv. Mallika TSS was highest on 140 DAFS (20.18 °brix). According to Anila and Radha (2003) [3], the TSS of ripe mango local varieties in Kerala varied widely from 10 to 24 °Brix, which conforms with the present research. Total soluble solids are determined by the hydrolysis of polysaccharides and their conversion to sugars.

Acidity was found to be decreasing as maturity has advanced. In mango cv. Ratna acidity ranged from 0.30% to 1.19% and lowest acidity was reported in ripe mature fruit (0.30%). In cv. Mallika acidity ranged from 0.73% to 1.56% lowest acidity was reported in ripe mature fruit (0.73%). The conversion of citric acid into sugars, which were used by fruit in its metabolic process, was attributed well with decrease in acidity (Lee *et al.*, 2010) [12].

Mango cultivars varied in ascorbic acid content during different growth stages wherein the initial period of growth ascorbic content was more and as fruit matured it decreased significantly. In mango cv. Ratna highest ascorbic acid (69.05 mg/100g) was seen in 90 DAFS and lowest in 110 DAFS (33.48 mg/100g). Anila and Radha (2005) [3] reported that

ascorbic acid content mango cv. Ratna is 31.30 mg/100g which conforms to the present study. In mango cv. Mallika highest ascorbic acid (80.38 mg/100g) was noted in 90 DAFS, and lowest in 140 DAFS (61.21 mg/100g). The higher level of ascorbic acid could be due to the continuous synthesis of glucose 6- phosphate, which is a precursor to ascorbic acid, during the growth and development of fruits (Hada and Singh, 2018) [8].

Sugar levels differed significantly in both the cultivars. It was less during the early stages of growth and gradually increased as the fruit matures. In cv. Ratna highest total sugar reducing sugar and non-reducing sugar (19.04%, 2.73% and 16.31%) was detected in 110 DAFS. The present result was confirming the finding of Anila and Radha (2005) [3] who recoded 20.66% and 2.97%, total and reducing sugar respectively. In cv. Mallika maximum sugars i.e. total, reducing and non-reducing sugar was noted in 140 DAFS (17%, 4.7% and 12.30%) followed by 120 (11.98%, 2.63% and 9.35%). The present result was similar to the findings of Bora *et al.* (2017) who recorded 20.82%, 4.98% and 15.04% of total, reducing and non-reducing sugar. The sweetness of the fruit may be due to the conversion of starch, acids, and other insoluble substances into soluble form during ripening.

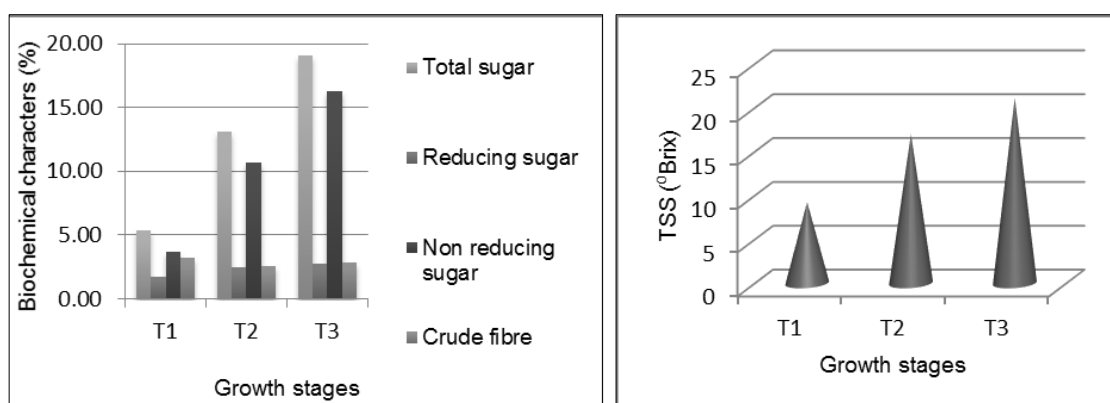


Fig 1: Effect of stages of development on sugars, TSS and crude fibre in mango cv. Ratna

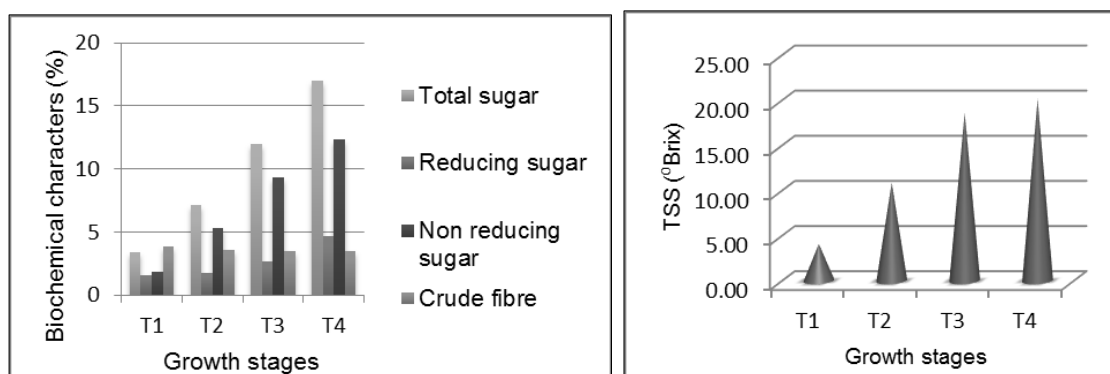


Fig 2: Effect of stages of development on sugars, TSS and crude fibre in mango cv. Mallika

Total phenol content differed significantly during different stages of growth stages. In cv. Ratna highest phenol content (74 mg/100g) was observed in 90 DAFS followed by 100 (55.20 mg/100g) and 110 DAFS (32.06 mg/100g). In cv. Mallika highest phenol content (57.5 mg/100g) was noticed in 90 DAFS followed by 120 (50.63 mg/100g), 140 (47.5 mg/100g) and 110 DAFS (26.25 mg/100g). Wide range was observed in phenolic content in mango from 68 mg GAE/100g to 266 mg GAE/100g (Wu *et al.*, 2004) [19]. Differences in variety, climate, maturation, extraction method, and agricultural system can all contribute to this variation.

In cv. Ratna highest carotenoid (65.88 mg/100g) was recorded in 90 DAFS followed by 100 (27.93 mg/100g) and 110 DAFS (14.65 mg/100g). In cv. Mallika and highest (56.26 mg/100g) was noted in 90 DAFS, followed by 110 (43.76 mg/100g), 120 (29.28 mg/100g) and 140 DAFS (7.56 mg/100g). Similar findings was recorded by Bora *et al.* (2017) were they found total carotenoid content of cv. Mallika is 7.42 mg/100g. Hoda *et al.* (2003) [7] found variations in total carotenoids content ranging from 2.33 mg/100 g to 44.95 mg/100g. Biosynthesis, degradation, and stable storage all contribute to carotenoid accumulation in chromoplasts seen on in the peel and flesh (Nisar *et al.*, 2015) [15].

In mango cv. Ratna, highest β -carotene (0.88 mg/100g) was spotted in 110 DAFS, followed by 100 (0.11 mg/100g) and 90 DAFS (0.05 mg/100g). In mango cv. Mallika, highest β -carotene (0.03 mg/100g) was remarked in 140 DAFS, followed by 120 (0.03 mg/100g), 110 (0.02 mg/100g) and 90 DAFS (0.02 mg/100g). Mango fruits develop pigments during

ripening as a result of carotenoid biosynthesis, changes in carbohydrates or starch conversion to sugars, organic acids, phenolics, and volatile compounds, resulting in ripening and softening to acceptable quality (Gill and Jawandha, 2008) [6].

In mango cv. Ratna, chlorophyll content was steady (0.01 mg/100g). During four growth stages in mango cv. Mallika, significant difference was observed in chlorophyll content and highest in 90 DAFS (0.03 mg/100g), followed by 110 (0.02 mg/100g), 120 (0.02 mg/100g) and 140 DAFS (0.01 mg/100g). The yellowing of the mangoes was most likely caused by chlorophyll breakdown and carotenoid synthesis in conjunction with the underlying pulp carotenoid.

In Kerala, heat unit (HU) requirement in cv. Ratna for 90, 100 and 110 DAFS is 989.05, 1023.35 and 1107.75 respectively and in cv. Mallika during four growth stages, the heat unit requirement was 957.65, 1185.70, 1314.70 and 1507.00 for 90, 110, 120 and 140 DAFS respectively, because of the temperature prevailing in this region. Rai *et al.* (2003) [16] reported that total degree days required for cv. Mallika 2238.63 HU which was similar with present study. By recording HU, days to maturity can be fixed in these varieties in Kerala.

In mango cv. Ratna, at 110 DAFS recorded the highest score in all the attributes (appearance, colour, taste, odour, overall acceptability and total score) and it is followed by 100 DAFS. In mango cv. Mallika, at 140 DAFS recorded the highest score in all the attributes (appearance, colour, taste, odour, overall acceptability and total score) and it is followed by 120 DAFS.

Table 5: Biochemical parameters of mango cv. Ratna

Treatments	TA (%)	AA (mg/ 100g)	TP (mg/ 100g)	Tc (mg /100g)	β -carotene (mg/ 100g)	TC (mg/ 100g)
T ₁	1.19	68.88	74.00	65.88	0.05	0.01
T ₂	0.56	69.05	55.20	27.93	0.11	0.01
T ₃	0.30	33.48	32.06	14.65	0.88	0.01
SE(d)	0.09	2.17	4.08	12.90	0.06	0.01
CD	0.19	4.78	8.99	28.42	0.133	NS

T₁ - 90 Days after fruit set, T₂ - 100 Days after fruit set, T₃-110 Days after fruit set, TA-titratable acidity, AA-ascorbic acidity, TP-total phenol, Tc-total carotenoid, fiber, TC-total chlorophyll

Table 6: Biochemical parameters of mango cv. Mallika

Treatments	TA (%)	AA (mg/ 100g)	TP (mg/ 100g)	Tc (mg /100g)	β -carotene (mg/ 100g)	TC (mg/ 100g)
T ₁	1.56	80.38	57.5	56.26	0.02	0.03
T ₂	1.28	77.95	26.25	43.76	0.02	0.02
T ₃	0.86	69.56	50.63	29.28	0.03	0.02
T ₄	0.73	61.21	47.5	7.563	0.03	0.01
SE(d)	0.29	3.06	7.50	3.56	0.001	0.003
CD	0.63	6.74	16.51	7.84	0.004	0.01

T₁ - 90 Days after fruit set, T₂- 110 Days after fruit set, T₃-120 Days after fruit set, T₄ - 140 Days after fruit set, TA-titratable acidity, AA-ascorbic acidity, TP-total phenol, Tc-total carotenoid, CF-crude fiber, TC-total chlorophyll

Table 7: Sensory evaluation of mango cv. Ratna

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Mean	Total score
T ₁	6.00 (1.10)	6.00 (1.20)	6.20 (1.40)	6.40 (1.40)	5.60 (1.30)	6.20 (1.10)	6.60 (1.40)	6.00 (1.00)	6.20	49.6
T ₂	7.00 (2.20)	6.80 (2.40)	7.20 (1.90)	7.00 (2.10)	7.20 (2.10)	7.40 (2.20)	7.20 (2.10)	7.00 (2.00)	7.20	57.2
T ₃	7.80 (2.70)	6.80 (2.40)	8.20 (2.70)	7.40 (2.50)	7.40 (2.60)	8.00 (2.70)	7.60 (2.50)	8.00 (3.00)	7.50	60.2
K	0.71	0.80	0.54	0.39	0.45	0.74	0.48	1.00		

T₁- 90 Days after fruit set, T₂- 100 Days after fruit set, T₃-110 Days after fruit set.

The values in parenthesis represents mean rank value

K – Kendall's co-efficient

Table 8: Sensory evaluation of mango cv. Mallika

Treatments	Appearance	Colour	Flavour	Texture	Odour	Taste	After taste	Overall acceptability	Mean	Total score
T ₁	7.00 (1.88)	6.75 (1.88)	6.00 (1.12)	6.00 (1.25)	6.00 (1.25)	5.75 (1.00)	6.25 (1.12)	6.00 (1.12)	6.22	49.75
T ₂	7.00 (1.88)	6.25 (1.25)	7.00 (2.25)	6.75 (2.38)	6.50 (1.88)	7.00 (2.12)	7.00 (2.12)	6.75 (2.00)	6.78	54.25
T ₃	7.25 (2.25)	7.50 (3.25)	7.25 (2.88)	7.25 (2.88)	7.25 (3.00)	7.75 (3.00)	7.75 (3.25)	7.50 (3.00)	7.44	59.50
T ₄	8.25 (4.00)	7.75 (3.62)	8.00 (3.75)	7.75 (3.50)	8.50 (3.88)	8.50 (3.88)	8.00 (3.50)	8.25 (3.88)	8.13	65.00
K	0.92	0.89	0.81	0.62	0.91	0.95	0.87	0.93		

T₁- 90 Days after fruit set, T₂- 110 Days after fruit set, T₃-120 Days after fruit set, T₄ - 140 Days after fruit set

The values in parenthesis represents mean rank value.

K – Kendall's co-efficient

Conclusion

The study revealed that in mango cv. Ratna ripe mature stage was at 110 DAFS with accumulation of 1107.75 HU where as in cv. Mallika it was 140 DAFS with accumulation of 1507 HU. At these stages have maximum marketable fruits with good quality parameters were obtained when harvested at their respective maturity stages under tropical humid conditions of Kerala.

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